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AQUAPONICS: A NEW TREND IN FOOD PRODUCTION

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ABSTRACT

The increase in population coupled with current and escalating extent of soil degradation, water scarcity and climate-related challenges plaguing agricultural productivity in every corner of the world and particularly in Nigeria demands for alternative food techniques, one of them called aquaponics. This paper highlights a new trend in food production techniques for the production of fish and vegetable crops in aquaponics. Aquaponics is experiencing renewed interest worldwide with many small home growers and large operations employing the process as a means of producing sustainable fish and plant crops. The design of this scalable farming system closely mirrors that of recirculating systems in general, with the addition of a hydroponic component and the possible elimination of a separate biofilter and devices for removing fine and dissolved solids. The benefits of aquaponics includes conservation of water resources and plant nutrients, intensive production of fish and reduced operating costs relative to either system in isolation. Aquaponics, without doubt is a practice that is receiving considerable interest due to an ever increasing need for fresh wholesome food and sustainable eco-friendly agricultural practices.

Key words: Aquaculture, hydroponics, recirculating system, sustainable ecosystem, natural fertilizer.

INTRODUCTION

The increase in human population and reports of large numbers of undernourished people, especially in the developing countries, has made the need for food production a major worldwide issue of concern (FAO, 2009). In Nigeria, the main challenges currently facing government are to eradicate poverty, attain food security, agricultural competitiveness and the sustainable management of her resources to achieve broad economic development (Oyedipe, 2009). Aquaculture, fisheries and agriculture have been identified as the three main groups of activities that contribute to food production (Borlaug, 2000). Recent studies show that the world's natural stocks of fish and shell fish, though renewable, have finite production limits, which cannot be exceeded even under the best management regimes. For most of the lakes, rivers and oceans, maximum sustainable fishing limit has been exceeded (FAO, 2001). Therefore, fish production will depend on aquaculture to bridge the gap of fish supply (Tacon, 2001).

Moreover, Current methods of large-scale aquaculture systems are not sustainable, and pose a threat not only to wild fish stocks but also to the environment. The discharge of untreated aquaculture effluent poses a serious environmental threat, even when treated; the continuous discharge of aquaculture effluent into open waters may impose negative environmental impacts (Considine, 2007). To minimize these impacts on the environment, innovative methods are now being explored to promote sustainable aquaculture production. One of such methods is the re-utilization of aquaculture effluent in value-added commercial applications. Similarly, the current and escalating extent of soil degradation, water scarcity and climate-related challenges plaguing agricultural productivity in every part of the world and particularly in Nigeria demands for alternative food techniques, one of them called Aquaponics (Connoly, 2010). Aquaponics, also known as the integration of hydroponics with aquaculture, is gaining increased global attention as a bio-integrated food production system. It is a concept relatively new to modern food production methods and can contribute to food security. The technology combines the two well-established practices of aquaculture and hydroponics to yield a method of food growing that greatly reduces the use of water resources, demands no soil, and produces high yields of fresh, nutritious crops in the form of vegetables, fruits, herbs etc. and fish. The development of aquaponics has been driven by different needs in different parts of the world, including a desire to efficiently utilize valuable resources (such as water), improve food security on subsistence family farms and minimize pollution (Malcolm, 2007). In Nigeria today, population is becoming concentrated in and around large cities and as the cities expand so does the urban consumer demand for food. Aquaponics will form part of the solution to this huge problem that is needed if we are to move towards individual and national food security. This paper was borne out of the need to draw attention to this new technology for abundance food production.

What is Aquaponics?

Aquaponics is a refined branch of aquaculture. The word 'aquaponics' is derived from a combination of 'aquaculture' (fish farming) and 'hydroponics' (growing plants without soil), and refers to the integration of hydroponic plant with aquaculture (Wikipedia, 2011). It is a bio-integrated system linking recirculating aquaculture with hydroponic production of plants such as vegetables, ornamental flowers, medicinal herbs, etc. Subhrankar

(2011) defined aquaponics as "an environmentally-friendly, natural food growing method that harnesses the best attributes of intensive aquaculture and hydroponics without the need to discard any water or filterate or add chemical fertilizers, and capitalizes on the benefits and eliminates the drawbacks of either". Aquaponic systems from definitions can mean recirculating aquaculture systems that incorporate the production of plants without soil to optimize the economic and environmentally sustainable use of energy, resources and infrastructure (Figure 1).

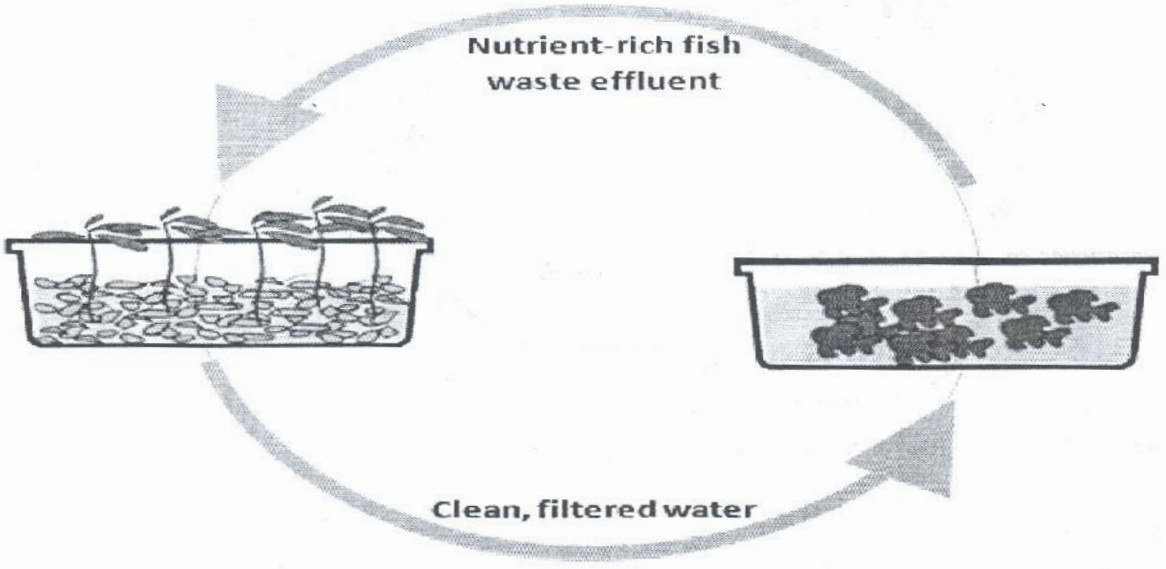

Figure 1: Conceptual diagram of the nutrient recycling in aquaponic systems (Suits, 2010).

Reasons for Aquaponics

Aquaponics is a highly innovative, efficient and sustainable agriculture method that combines aquaculture and hydroponics. Nutrient rich water from aquaculture provides natural fertilizer to the plants in the hydroponics system. In return, the plants return clean, freshwater to the fish (Figure 1). Overall, aquaponics conserves water; it is a natural food production system which involves no herbicides or pesticides application, eliminates any soil-borne diseases that may be carried by plants, and is compact, thereby, maximizing space while increasing food production (Diver, 2006). Although the science of aquaponics is still in the early stage, the biochemical engine that drives the aquaponics system, known as the nitrogen cycle (Figure 2), which symbiotically provides fertility to the plants and cleans the water for the fish in a fish-plant aquaponic system, is fairly well understood.

The recent food and financial crises have highlighted the problem of urban food insecurity in developing countries (FAO, 2009). Currently however, the important relationship between food security, agriculture and urbanization still require more recognition. Aquaponics forms part of the solution to this huge problem that is needed if we are to move towards individual and global food security.

Aquaponics design

The essential elements of an aquaponics system are the fish-rearing tank, a settleable and suspended solids removal component, a biofilter, a hydroponic component, and a sump (Figure 3). However, aquaponic systems should ideally be designed so that the hydroponic subsystem also serves as the biofilter, which eliminates the capital cost and operational expense of a separate biofilter. Similar to Recirculating Aquaculture System (RAS), culture tanks hold fish and water required to raise the fish in an aquaponic system with exception of the growbeds which use troughs that are relatively small compared to the fish tanks. Most commercial growers use a greenhouse to protect the plants and fish from harsh environmental conditions and pest insects.

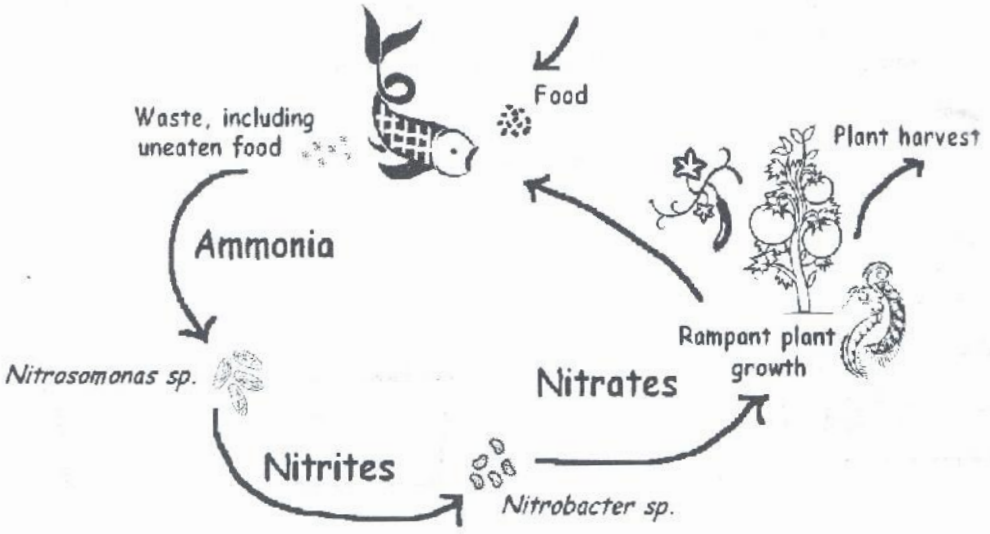

Figure 2: Schematic diagram of Nitrogen Cycle (Steve, 2007)

The production can be very high in a commercial aquaponic system when plant spacing is maximized and the fish are fed a proper and balanced diet. The daily work involved in a commercial aquaponic venture includes feeding the fish and cleaning the filters, seeding, transplanting and harvesting the plants and packaging the produce for sale. The fish are harvested periodically, with the frequency dependant on the size of the system, the number of fish tanks and the market demand. Most freshwater species (including ornamental fish) which can tolerate crowding will do well in aquaponic systems. Several warm-water fish species such as tilapia and African catfish can adapted to aquaponic systems. The selection of plant species adapted to hydroponic culture in aquaponic greenhouses is related to stocking density of fish tanks and subsequent nutrient concentration of aquacultural effluent. Several plants that are well adapted to aquaponic systems include lettuce, spinach, cucumbers, tomatoes and peppers (Diver, 2006). To recover the capital cost and operating expenses of aquaponic systems and thereby earning profit, both the fish rearing and the hydroponic vegetable components must be operated continuously near maximum production capacity. The maximum biomass of fish a system can support without restricting fish growth is called the critical standing crop (Rakocy, 2006). Operating a system near its critical standing crop uses space efficiently, maximizes production and reduces variation in the daily feed input to the system - an important factor in sizing the hydroponic component.

CONCLUSION

Aquaponic system is quite simple to set up and can, possibly, open up a completely new world when it comes to organic farming. It creates a (loosely) closed loop system where the fish provide the nourishment for the plants by the nitrogen cycle and in return, plants clean and filter out the ammonia sending clean water back to the fish. Aquaponic systems are not only eco-friendly, sustainable, provide food security and create sustainable livelihood, but they are also commercially feasible and make good business sense especially in a world of dwindling and escalating costs of natural resources, such as land and water. In essence, this alternative food production method is obviously of major importance to meet higher demand.

119. Ahmed, M. (1966)
Report on fisheries survey of Kainji Dam area. *Northern Region Ministry Agriculture, Kaduna. Appendix I (Mimeo)*

120. Ahmed, Y.B.; A.A. Eyo and M.T. Maigari (2006)
Assessment of alternative sources of income for Artisanal fishermen in Kainji Lake, Nigeria. In: *Proceedings of 20th Annual Conference of Fisheries Society of Nigeria* held at Port Harcourt 14-18 Nov. 2005. P. 475-481.

121. Ahmed, Y.B.; S. Abubakar and M.M. Bako (2007)
Assessment of safety of water craft in Lake Kainji. In: *Proceedings of the Annual Conference of Fisheries Sociekty of Nigeria* held at Calabar, 13-17 Nov. 2006. p.73-78

122. Ahmed, Y.B.; J.K. Ipinjolu; U.M. Yauri; Y.B. Abubakar (2007)
Relative efficiency of monofilament and multifilament trammel nets in Southern portion of Lake Kainji, Nigeria. In: *Proceeding of the 21st Annual Conference of Fisheries Society of Nigeria* held at Calabar 13-17 Nov. 2006. p.66-72.

123. Ahmed, Y.B. and J.K. Ipinjolu (2006).
Selectivity of gillnets and baited longlines in the Southern basin of Lake Kainji, Nigeria. In: *Proceedings of the 20th Annual Conference of Fisheries Society of Nigeria* held at Port-Harcourt 14-18 Nov. 2005. P.334-346.

124. Ahmed, Y.B.; J.K. Ipinjolu and W.A. Hassan (2006).
Catch composition of gillnets and baited longlines in the Southern basin of Lake Kainji, Nigeria. In: *Proceedings of the 20th Annual Conference of the Fisheries Sociekty of Nigeria* held at Port Harcourt. 14-18 Nov. 2005. p.350-360.

125. Aiyedun, B.A. and J.D. Adegboye (1967)
River fisheries surveys in Northern Nigeria. *Nigerian Field.* 32. P.160-170

126. Ajayi, T.O. (1972)
Biological studies on the family Bagridae (Pisces: Silorides) in Lake Kainji, Nigeria. M.Phil. thesis submitted to the Department of Zoology, University of Ife, Nigeria.

127(a). Akinpelu, A.I. (1983)
Studies on the parasites of fish in the kainji Lake M.Sc. thesis, Department of Zoology, University of Ibadan

119. Ahmed, M. (1966)
Report on fisheries survey of Kainji Dam area. *Northern Region Ministry Agriculture, Kaduna. Appendix I (Mimeo)*

120. Ahmed, Y.B.; A.A. Eyo and M.T. Maigari (2006)
Assessment of alternative sources of income for Artisanal fishermen in Kainji Lake, Nigeria. In: *Proceedings of 20th Annual Conference of Fisheries Society of Nigeria* held at Port Harcourt 14-18 Nov. 2005. P. 475-481.

121. Ahmed, Y.B.; S. Abubakar and M.M. Bako (2007)
Assessment of safety of water craft in Lake Kainji. In: *Proceedings of the Annual Conference of Fisheries Sociekty of Nigeria* held at Calabar, 13-17 Nov. 2006. p.73-78

122. Ahmed, Y.B.; J.K. Ipinjolu; U.M. Yauri; Y.B. Abubakar (2007)
Relative efficiency of monofilament and multifilament trammel nets in Southern portion of Lake Kainji, Nigeria. In: *Proceeding of the 21st Annual Conference of Fisheries Society of Nigeria* held at Calabar 13-17 Nov. 2006. p.66-72.

123. Ahmed, Y.B. and J.K. Ipinjolu (2006).
Selectivity of gillnets and baited longlines in the Southern basin of Lake Kainji, Nigeria. In: *Proceedings of the 20th Annual Conference of Fisheries Society of Nigeria* held at Port-Harcourt 14-18 Nov. 2005. P.334-346.

124. Ahmed, Y.B.; J.K. Ipinjolu and W.A. Hassan (2006).
Catch composition of gillnets and baited longlines in the Southern basin of Lake Kainji, Nigeria. In: *Proceedings of the 20th Annual Conference of the Fisheries Sociekty of Nigeria* held at Port Harcourt. 14-18 Nov. 2005. p.350-360.

125. Aiyedun, B.A. and J.D. Adegboye (1967)
River fisheries surveys in Northern Nigeria. *Nigerian Field.* 32. P.160-170

126. Ajayi, T.O. (1972)
Biological studies on the family Bagridae (Pisces: Silorides) in Lake Kainji, Nigeria. M.Phil. thesis submitted to the Department of Zoology, University of Ife, Nigeria.

127(a). Akinpelu, A.I. (1983)
Studies on the parasites of fish in the kainji Lake M.Sc. thesis, Department of Zoology, University of Ibadan

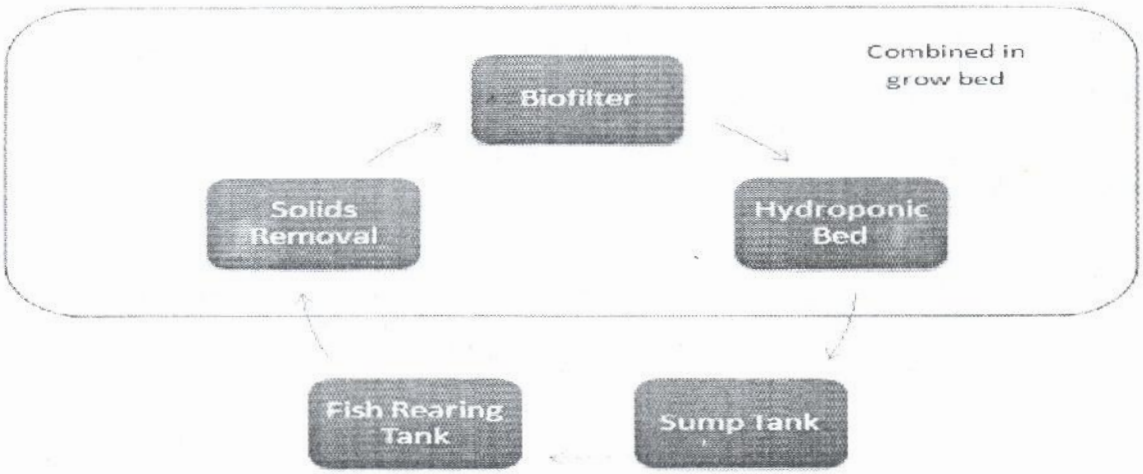

Figure 3: Flow chart of general system components arrangement of aquaponics (Rakocy *et al.*, 2006)

REFERENCES

Borlaug, N. 2000. The Green Revolution Revisited and the Road Ahead, http://nobelprize. virtual.museum /peace/ articles/borlaug/borlaug-lecture.pdf. Accessed Jan. 4, 2006.

Considine, M. 2007. Plant crops to clean up aquaculture waste. *ECOS Magazine*, Aug-Sept. p.44

Diver, S. 2006. *Aquaponics—Integration of Hydroponics with Aquaculture.* ATTRA—National Sustainable Agriculture Information Service (National Center for Appropriate Technology).

Food and Agricultural Organization (FAO), 2009. Food for the Cities multidisciplinary initiative: http://www.fao.org/fcit October 2009

Food and Agricultural Organization (FAO), 2001. The State of World Fisheries and Aquaculture. Rome, Italy Pp394

Malcolm, J. 2007. The Start of an Obsession. Backyard Aquaponics. The No.1 Aquaponics Magazine for the Backyard Enthusiast. Issue 1. Summer 2007. Pg. 4-17

Oyedipe E.O. 2009. Nigeria: National Food Crisis Response Programme Validation Workshop Held on Tuesday, August 4, 2009 @ FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, UN HOUSE, ABUJA.

Rakocy, J. E., Masser, M. P., & Losordo, T. M. (2006). Recirculating Aquaculture Tank Production Systems: Aquaponics - Integrating Fish and Plant Culture. *Southern Regional Aquaculture Center, Publication No. 454* , 1-16.

Subhrankar M. 2011. Aquaponics Systems and Technologies to Showcase Sustainable Food Security Initiatives in Urban and Village-based Communities. Sankalpa Research Center SRC/ATD/AP.01 Revision 1. 25th August 2011.

Suits, B. 2010. Access to Personal Agriculture. *The Aquaponics Guidebook, Volume 1, 2nd Edition* , pp. 1-12.

Tacon, A.G.J. 2001: Increasing the contribution of aquaculture for food security and poverty alleviation. In R. P. Subasinghe, P. Bueno, M. J. Philips, C. Hough, S. E. McGladdery and J.R. Arthur, eds. Aquaculture in the Third Millenium. Technical Proceedings of the Conference on Aquaculture in the Third Millenium, Bangkok, Thailand, 20 – 25 February 2000. Pp 63 – 72. NACA, Bangkok and FAO, Rome.

Wikipedia, 2011. "Aquaponics" Wikipedia, The Free Encyclopedia, April 25, 2011, http://en.wikipedia.org/wiki/Aquaponics.